Complete Summary

GUIDELINE TITLE

ACR Appropriateness Criteria™ for imaging of intracranial infections.

BIBLIOGRAPHIC SOURCE(S)

Deck MD, Drayer BP, Anderson RE, Braffman B, Davis PC, Hasso AN, Johnson BA, Masaryk T, Pomeranz SJ, Seidenwurm D, Tanenbaum L, Masdeu JC. Imaging of intracranial infections. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):535-45. [39 references]

COMPLETE SUMMARY CONTENT

SCOPE

DISEASE/CONDITION(S)

Intracranial infections

GUIDELINE CATEGORY

Diagnosis

CLINICAL SPECIALTY

Infectious Diseases
Internal Medicine
Neurology
Radiology

INTENDED USERS

Health Plans
Hospitals

Managed Care Organizations
Physicians
Utilization Management

GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for intracranial infections

TARGET POPULATION

Patients with intracranial infections

INTERVENTIONS AND PRACTICES CONSIDERED

1. Plain x-ray
2. Computed tomography:
    - No contrast
    - With contrast
3. Magnetic resonance:
    - Magnetic resonance imaging no contrast
    - Magnetic resonance imaging with contrast
    - Magnetic resonance angiography/Magnetic resonance venography
    - Magnetic resonance diffusion
    - Magnetic resonance spectroscopy
4. Cerebral angiography
5. Tomograms
6. Single-photon emission computed tomography:
    - Hexamethyl propylene amine oxime
    - Thallium
7. Positron emission tomography with fluorodeoxyglucose

MAJOR OUTCOMES CONSIDERED

Utility of radiologic examinations in differential diagnosis

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of recent peer-reviewed medical journals, primarily using the National Library of Medicine's MEDLINE database. The developer identified and collected the major applicable articles.

NUMBER OF SOURCE DOCUMENTS

The total number of source documents identified as the result of the literature search is not known.

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Expert Consensus (Delphi Method)
Weighting According to a Rating Scheme (Scheme Not Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not applicable

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders within a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed to reach agreement in the formulation of the Appropriateness Criteria. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by the participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1-9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty (80) percent agreement is considered a consensus. If consensus cannot be reached by this method, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of each test or procedure are discussed and consensus reached whenever possible.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

METHOD OF GUIDELINE VALIDATION

Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria and the Chair of the ACR Board of Chancellors.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria™

Clinical Condition: Intracranial Infections

Variant 1: Headache, fever, neck stiffness, rule out meningitis.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	
• Magnetic resonance diffusion	4	
• Magnetic resonance spectroscopy	2	

Computed tomography		
• Computed tomography no contrast	6	
• Computed tomography with contrast	5	If magnetic resonance is not available.
Cerebral angiography	3	To rule out subarachnoid hemorrhage or arteritis.
Plain x-rays	2	
Tomograms	2	
Single-photon emission computed tomography hexamethyl propylene amine oxime	2	
Single-photon emission computed tomography thallium	2	
Positron emission tomography with fluorodeoxyglucose	2	
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 2: Headache, fever, neck stiffness. Chronic sinusitis or ear infections.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Computed tomography		
• Computed tomography no contrast	8	
• Computed tomography	6	

with contrast		
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	Needed if venous thrombosis is suspect.
• Magnetic resonance diffusion	4	
• Magnetic resonance spectroscopy	2	
Plain x-rays	4	
Cerebral angiography	3	
Tomograms	2	
Single-photon emission computed tomography hexamethyl propylene amine oxime	2	
Single-photon emission computed tomography thallium	2	
Positron emission tomography with fluorodeoxyglucose	2	
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 3: Recent meningitis. Rule out empyema or abscess.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	Needed if venous thrombosis is suspect.
• Magnetic resonance diffusion	4	
• Magnetic resonance spectroscopy	3	
Computed tomography		
• Computed tomography no contrast	6	
• Computed tomography with contrast	6	
Cerebral angiography	4	
Plain x-rays	2	
Tomograms	2	
Single-photon emission computed tomography hexamethyl propylene amine oxime	2	
Single-photon emission computed tomography thallium	2	
Positron emission	2	

tomography with fluorodeoxyglucose		
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 4: Recent cranial nerve palsies. Suspect sarcoid.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	
• Magnetic resonance diffusion	4	
• Magnetic resonance spectroscopy	2	
Computed tomography		
• Computed tomography no contrast	4	
• Computed tomography with contrast	4	If magnetic resonance is not available.
Cerebral angiography	3	If 3rd nerve palsy with pupillary involvement, angiogram may be

		indicated. Selected cases for arteritis.
Plain x-rays	2	
Tomograms	2	
Single-photon emission computed tomography hexamethyl propylene amine oxime	2	
Single-photon emission computed tomography thallium	2	
Positron emission tomography with fluorodeoxyglucose	2	
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 5: Headache, fever, clouded sensorium. Rule out encephalitis.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	
• Magnetic resonance diffusion	4	

• Magnetic resonance spectroscopy	3	
Single-photon emission computed tomography hexamethyl propylene amine oxime	5	
Computed tomography		
• Computed tomography no contrast	4	If magnetic resonance is not available or emergency situation.
• Computed tomography with contrast	4	
Positron emission tomography with fluorodeoxyglucose	3	
Plain x-rays	2	
Tomograms	2	
Single-photon emission computed tomography thallium	2	
Cerebral angiography	2	
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 6: HIV positive patient. Focal neurological deficit.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	

• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	4	
• Magnetic resonance diffusion	4	May assist in difficult distinction of abscess vs. lymphoma.
• Magnetic resonance spectroscopy	3	
Computed tomography		
• Computed tomography no contrast	6	
• Computed tomography with contrast	6	If magnetic resonance is not available or emergency situation.
Single-photon emission computed tomography thallium	5	If distinction of lymphoma vs infection is needed after positive post contrast magnetic resonance or computed tomography.
Single-photon emission computed tomography hexamethyl propylene amine oxime	4	
Cerebral angiography	2	
Plain x-rays	2	
Tomograms	2	
Positron emission tomography with fluorodeoxyglucose	No Consensus	Insufficient data.
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Clinical Condition: Intracranial Infections

Variant 7: Seizures or other focal deficit, suspect intracranial calcifications, e.g., cysticercosis.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Magnetic resonance		
• Magnetic resonance imaging no contrast	8	
• Magnetic resonance imaging with contrast	8	
• Magnetic resonance angiography, Magnetic resonance venography	2	
• Magnetic resonance spectroscopy	2	
• Magnetic resonance diffusion	2	
Computed tomography		
• Computed tomography no contrast	6	Important for detecting calcifications.
• Computed tomography with contrast	6	
Plain x-rays	4	
Tomograms	2	
Single-photon emission computed tomography hexamethyl propylene amine oxime	2	
Single-photon emission computed tomography thallium	2	

Positron emission tomography with fluorodeoxyglucose	2	
Cerebral angiography	2	
Appropriateness Criteria Scale 1 2 3 4 5 6 7 8 9 1=Least appropriate 9=Most appropriate		

Summary

The most common clinical manifestations of central nervous system infection include fever, headache, alteration of mental status, and focal neurological signs. These clinical findings, may also be associated, however, with other noninfectious syndromes such as primary brain tumors; therefore, their presence is relatively nonspecific. Since the advent of computed tomography and magnetic resonance imaging, the diagnosis of intracranial infections has become significantly more accurate, leading to earlier treatment and improvement of survival.

Brain Abscesses

Brain abscesses may result from a wide variety of infectious organisms, including gram positive and gram negative bacteria and various fungi. Blood-borne abscesses may develop in the brain as a result of cyanotic heart disease, pulmonary arterio-venous fistula, and bacterial endocarditis. Direct spread of organisms may also result in brain abscesses as a complication of sinusitis, chronic otitis and mastoiditis, and post-traumatic or congenital transgression of the dura. Intracerebral abscesses may also develop by direct venous spread from such extradural infections. The early diagnosis of a brain abscess or its earlier stage of "cerebritis" results in appropriate treatment, including the careful selection of antibiotics, drainage of the abscess cavity, and correction of the original source of the infection, particularly if the abscess is secondary to sinus or middle ear infection. Since the introduction of computed tomography, the overall mortality of abscesses has decreased from more than 40% to less than 5%. Magnetic resonance imaging performed without and with contrast enhancement using gadolinium agents is considered to be superior to computed tomography without and with contrast because the magnetic resonance imaging demonstrates epidural and subdural extension of the inflammatory process better and is able to show the relationship of an abscess cavity to the cerebral ventricles. In addition, magnetic resonance imaging demonstrates almost pathognomonic findings in a mature abscess due to the shortening of the T1 and T2 relaxation times in the abscess wall, resulting in hyperintensity on T1-weighted and hypo-intensity on T2-weighted images. Magnetic resonance imaging, and particularly magnetic resonance angiography may also be useful for demonstration, secondary venous occlusive disease, a frequent complication of chronic mastoiditis with superimposed acute infection. Cerebral arteriography is the gold standard for such changes, however. Computed tomography is considered superior for demonstrating bone abnormalities in inflammatory ear disease and may also

provide useful additional information in cases of sinusitis. Computed tomography or magnetic resonance imaging is also necessary for stereotactic aspiration of abscess cavities. Magnetic resonance spectroscopy may be useful in the demonstration of abscesses because specific resonance lines have been shown in the contents in the abscess. Several studies have suggested the value of triple-dose contrast with magnetic resonance imaging for increasing the perspicuity of abscesses and this may be further enhanced by magnetization transfer imaging techniques which, however, are not widely available and remain experimental. Magnetic resonance imaging and computed tomography also play important roles in less common inflammatory disease involving the brain such as nocardial abscesses and fungal infections such as mucormycosis and aspergillosis, where magnetic resonance imaging is superior because of specific findings, namely marked decrease or an absence of signal on the T2-weighted images.

Subdural and Epidural Empyema

Most cases of subdural or epidural empyema are secondary to sinusitis or middle ear infection, but they may also occur in infants and young children as a complication of acute bacterial meningitis particularly due to hemophilus influenza infections. Magnetic resonance imaging with contrast enhancement is considered superior to computed tomography with contrast enhancement because of its multiplanar capability. Accurate imaging is necessary to plan for surgical drainage. Chronic meningitis due to tuberculosis, sarcoid, syphilis, and other assorted organisms may result in hydrocephalus due to blockage at the tentorial and incisura or more distally at the arachnoid granulations, or it may present with cranial nerve palsies. Magnetic resonance imaging with contrast enhancement is superior to computed tomography because of its multiplanar capabilities and lack of artifacts around the skull base. Magnetic resonance imaging now used to follow the response to therapy. Extra axial collections of pus may be demonstrated by cerebral angiography; and vascular occlusions secondary to meningitis are also best shown with such techniques.

Meningitis

The primary diagnostic test for meningitis is lumbar puncture, which establishes the presences of inflammation, and following appropriate cultures also establishes the organism and its antibiotic sensitivity.

Magnetic resonance imaging or computed tomography is frequently used, however, to rule out a parameningeal focus of infection or the presence of an abscess or other mass lesion that may result in life-threatening brain herniation if a lumbar puncture was performed. They are now routine in some institutions, because of malpractice liability to perform an emergency computed tomography or magnetic resonance imaging before lumbar puncture in all patients with suspicion of meningitis.

Magnetic resonance or computed tomography also plays an important role in following complications of meningitis such as infarcts due to vasospasm or empyema. In incompletely treated meningitis, extensive infarction may develop as a result of vasospasm of the cerebral arteries requiring magnetic resonance angiography or cerebral angiography for elucidation.

Viral Infections

Viral encephalitis may be caused by many different organisms that may produce relatively nonspecific findings on computed tomography and magnetic resonance imaging. Herpes simplex virus type I and type II may produce a severe acute necrotizing meningoencephalitis in adults, although it may also be seen in infants and children. The patients present with acute confusion, disorientation, seizures, fever and headache, and there may be specific language impairment. Early clinical diagnosis is essential because treatment with vidarabine or acyclovir therapy may be life saving and may also prevent serious long-term neurological deficit. Both magnetic resonance imaging and computed tomography may show hypodensity, particularly involving the anterior and medial aspects of the temporal lobes, and areas of hemorrhage may be demonstrated on computed tomography and magnetic resonance imaging if appropriate imaging sequences such as gradient recalled acquisition in the steady state are obtained. Magnetic resonance imaging is considered significantly more sensitive than computed tomography in the early stages of the disease. A recent study recommended the use of hexamethyl propylene amine oxime brain single-proton emission computed tomography for the early diagnosis of herpes simplex, Epstein-Barr, and Japanese B virus encephalitis. In the evaluation of the late stages of the disease, which may be associated with various neurological disorders including memory deficits and dementia, magnetic resonance imaging with high resolution of the temporal lobes is advocated for demonstrating specific hippocampal, parahippocampal, and neocortical temporal lobe damage.

HIV Infection and AIDS

Computed tomography and magnetic resonance imaging are extensively used to assess patients with known HIV infection. Either computed tomography or magnetic resonance imaging may be used to evaluate infants and children for the effects of the primary disease and for the secondary complications such as toxoplasma infection. In adults, computed tomography or magnetic resonance imaging is routinely used before lumbar puncture to rule out the presence of life-threatening mass lesions. In the presence of a neurological deficit of recent onset in an HIV-positive patient, magnetic resonance imaging is the modality of choice for demonstrating toxoplasma granulomas, progressive multifocal leucoencephalopathy, and lymphoma. Magnetic resonance imaging is also superior for demonstrating changes in the white matter due to HIV-related encephalitis. The findings on magnetic resonance imaging, however, may not be pathognomonic and it may be difficult to differentiate lymphoma from toxoplasmosis. Thallium single-photon emission computed tomography radionuclide scans of the brain have been shown to differentiate inflammatory lesions from lymphoma with a high degree of accuracy. There is some evidence to indicate that positron emission tomography using fluorodeoxyglucose may have a similar ability to differentiate lymphoma from inflammatory lesions. In patients with cognitive impairment various studies have advocated the use of proton spectroscopy because of specific changes in N-acetyl aspartate and choline that are due to neuronal loss. Kieburtz et al showed specific findings in patients with HIV-related dementia complex, namely high signal abnormalities in the splenium of the corpus callosum and the hippocampus, but Cohen et al showed that routine magnetic resonance imaging was substantially normal in a population of non-AIDS HIV-positive males. Other opportunistic infections in immuno-compromised

patients include cryptococcoses, and magnetic resonance imaging is considered superior to computed tomography for demonstrating the findings of large Virchow-Robin spaces, parenchymal and leptomeningeal nodules, etc.

Syphilis is found as a complicating infection in patients with HIV. Findings on magnetic resonance imaging and computed tomography included contrast-enhancing mass lesions due to gumma dural thickening due to pachymeningitis and focal infarcts, and white matter abnormalities due to syphilitic arteritis. Arteritis may also be demonstrated by magnetic resonance angiography and arteriography. There is insufficient data to assess the accuracy of magnetic resonance angiography at this stage.

Cysticercosis and Other Parasitic Diseases

Magnetic resonance imaging and computed tomography now play an important role in the diagnosis of cerebral cysticercosis. Computed tomography demonstrates intracranial and muscle calcifications due to the dead larvae with a high degree of accuracy. On magnetic resonance imaging, however, calcifications are poorly seen but the area of surrounding gliosis and contrast enhancement is better demonstrated. Magnetic resonance imaging is also superior for demonstrating live intraventricular or cisternal cysticerci.

CLINICAL ALGORITHM(S)

Algorithms were not developed from criteria guidelines.

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

Appropriate selection of radiologic exams to diagnose intracranial infections in patients and provide early treatment to improve survival.

POTENTIAL HARMS

Not stated

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Getting Better

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Deck MD, Drayer BP, Anderson RE, Braffman B, Davis PC, Hasso AN, Johnson BA, Masaryk T, Pomeranz SJ, Seidenwurm D, Tanenbaum L, Masdeu JC. Imaging of intracranial infections. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):535-45. [39 references]

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

1996 (revised 1999)

GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

SOURCE(S) OF FUNDING

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria™.

GUIDELINE COMMITTEE

ACR Appropriateness Criteria™ Committee, Expert Panel on Neurologic Imaging

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Names of Panel Members: Thomas Masaryk, MD; Burton P. Drayer, MD; Robert E. Anderson, MD; Bruce Braffman, MD; Patricia C. Davis, MD; Michael D. F. Deck, MD; Anton N. Hasso, MD; Blake A. Johnson, MD; Stephen J. Pomeranz, MD; David Seidenwurm, MD; Lawrence Tanenbaum, MD; Joseph C. Masdeu, MD, PhD

FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

GUIDELINE STATUS

This is the current release of the guideline. It is a revision of a previously issued version (Appropriateness criteria for imaging of intracranial infections. Reston [VA]: American College of Radiology [ACR]; 1996. 11 p. [ACR Appropriateness Criteria™]).

The ACR Appropriateness Criteria™ are reviewed after five years, if not sooner, depending upon introduction of new and highly significant scientific evidence. The next review date for this topic is 2004.

GUIDELINE AVAILABILITY

Electronic copies: Available from the American College of Radiology (ACR) Web site.

Print copies: Available from ACR, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

AVAILABILITY OF COMPANION DOCUMENTS

None available

PATIENT RESOURCES

None available

NGC STATUS

This summary was completed by ECRI on July 31, 2001. The information was verified by the guideline developer as of August 24, 2001.

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